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# Implementing Ecosystem-based Fisheries Management: Lessons from Chile's experience

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ABSTRACT

The Ecosystem-based Fisheries Management (EBFM) paradigm has been incorporated in the new Chilean Fisheries Act, requiring Chile to transition into EBFM. Chile is a major fishing nation and has substantial industrial and artisanal fleets that provide significant social and economic benefits to Chile and its coastal communities. With Chile facing global challenges, such as food security and climate change, transitioning to EBFM is seen as a mechanism for improved management of Chile's marine resources. Using Chile as an example to review coherence, strategies and implication of policies for transitioning toward EBFM. In Chile, the implementation of EBFM, in general, appears to be making progress and should be able to be applied for all fisheries (and aquaculture). Despite positive outcomes, there are weaknesses that can harm the successful implementation of EBFM. Changes such as management councils and scientific committees structured around ecosystems rather than single species, the engagement of broader types of stakeholders, and the use of appropriate reference points are necessary for a strong implementation of EBFM. Incorporating these modifications under the current management framework would enable Chile to improve its implementation of EBFM and prepare its fisheries to address future management challenges under scenarios of change.

## 1. Introduction

Fisheries management is based on paradigms and rules controlling resource exploitation. As new information arises and societal desires shift, these rules and paradigms need to evolve. A recent example of this evolution is the shift towards Ecosystem-Based Fisheries Management (EBFM), or to the closely related Ecosystem Approach to Fisheries (EAF) [1,2]. This has seen fisheries management transition from a single-species approach, where the management is based only on a target species, to EBFM where there is an attempt to consider the whole ecosystem [2]. The rationale driving this shift in management is based on the recognition of the role of ecosystems in supporting sustainable fish stocks. Without such recognition, there will be ongoing damage to stocks previously affected by excessive fishing pressure (inhibiting recovery) or when there are impoverished environmental conditions. This realization has been driven by the collapse of a number of fisheries around the globe [3], the degradation of the supporting ecosystems due to human activities, and the impact of undesirable outcomes on the economy and society (i.e. poverty, inequities and social conflict) [4]. These detrimental outcomes have fostered the reformulation of management approaches, responding to pressure for change in fisheries management, with more recent explicit recognition of the need to incorporate new socio-ecological goals in management objectives: such as biodiversity [1,5] and the inclusion of a broader diversity of stakeholders and their objectives [1].

This paper explores the introduction of EBFM in Chile. This analysis centered on the concept of policy coherence [6,7] which provides a robust framework to review strategies and policies. The EBFM, or EAF, concepts are new in Chile and present diverse challenges for authorities, fishing industries, fishermen and for the scientific community.

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One of the main challenges is how to implement the EBFM approach in a way that suits and embraces the diversity of fisheries that operate in Chile, while recognizing the challenges in maintaining coherence in its implementation.

## 2. Implementing EBFM: a policy coherence lens

The concept of policy coherence is ambiguous [8], and often used synonymously with integration and coordination. It provides an important focus on outputs, as well as the policy development process [6]. It can be defined as "the attributes of policy that systematically reduce conflict and promote synergies between and within different policy areas" [6] while recognizing trade-offs and reconciling divergent objectives [9]. The initial focus on policy coherence addressed development studies and policy but has broadened to provide a rich and useful framework in a range of policy domains [7–9]. The vast majority of the literature on EBFM notes particular challenges with knowledge gaps, compartmentalized approaches to decision-making, limited stakeholder participation and challenges in integrating decisions at different scales [10]. These are key aspects of policy coherence and key elements likely to affect EBFM program development and implementation [11]. Few studies are grounded in empirical experiences and impacts of establishing EBFM, such as the performance of different management approaches against postulated ecosystem-based principles or goals and hence both the theoretical framing and empirical example discussed in this paper have broad relevance. Policy coherence focuses on the interplay between broader policy commitments and specific objective setting and implementation [7]; for example, a national commitment to an economically, ecologically and socially sustainable fishing industry and the commitments to a more focused ecosystem basis to fisheries management. Policy coherence allows the examination of both the development of specific objective setting but also its impacts on, and its influence by the broader (and often external) policy commitments. Implementation challenges or "policy failure" can arise as a result of incoherence between these two elements, with clear needs to address questions first for coherence rather than simply policy or program design. The Organization for Economic Co-operation and Development (OECD) recognises stakeholder involvement, knowledge management, commitment and leadership as key criteria in establishing policy coherence [9]. These core criteria highlight the key role of lead policy actors and their relationships with other stakeholders in developing and implementing policy, the key areas in assessing policy coherence. Our analysis adopts and adapts the work of Nilsson et al. [6] who present a three-step framework for the assessment of policy coherence; first an inventory of policy objectives; second a review of interactions and third an in-depth analysis of key interactions. We outline the development of new policy objectives, and legislation focusing on the shift to EBFM. The use of a policy coherence lens allows investigation of gaps and challenges with respect to institutional arrangements, management processes and policy tools in the implementation of EBFM. This analysis was performed using two sources of information contained in published literature (i.e. scientific manuscripts and technical-scientific reports) and the current Chilean fishing policies.

## 3. EBFM in Chile

Historically, Chilean fisheries have gone through three main stages which have been marked by the incorporation of new technologies and diversification of target species. This includes a pre-Hispanic aboriginal phase; a Hispanic small scale fisheries phase; and a phase of industrialization. These phases, which began at different times, currently coexist (more details Table 1). Although fishing in Chile can be dated from 9000 BCE, Chilean fisheries management only began in 1819 after the country´s independence [12]. From this beginning until 2013, fisheries management in Chile was based exclusively on a single-species approach (Table 2). Different management tools were put in place but

**Table 1**
Main historical milestones of fishing activity in Chile since pre-Hispanic times.

| Period | Year | Historical milestones | Description | Ref. |
|---|---|---|---|---|
| **Pre-Hispanic** | 9000 BCE | Primitive fishermen | | [68] |
| | 7000 BCE | Mixed economy | Based on fishing and other activities in the desert | [68] |
| | 5000 BCE | Development of the fishing hook | Increase in fishing activity, more people is moving to live in along the coast | [68] |
| | 3000 BCE | Specialization in fishing | Some indigenous peoples as the(e.g. Chinchorros in the north of Chile) were specialised in marine activities | [68] |
| | | Dependency exclusively on marine resources | Indigenous people, such as Chonos, Kawéshkar and Yámanas lived and depended exclusively on marine resources | [68] |
| | 16th century to 1970 CE | Decline of indigenous fishing activity | Extermination of the indigenous peoples, campaigns of cultural homogenisation and 'forced assimilation' (By the Spanish settlers and later by the Chilean government) | [68] |
| **Hispanic artisanal** | 16th century | small-scale coastal fishery | Supply small domestic market | [12] |
| | 18th to mid 20th century | Hunting of marine mammals | In the first stage undertaken primarily by foreign vessels, later carried out by Chilean nationals | [69,70] |
| | Early 1940 | Hake fishery (*Merluccius gayi gayi*) | For direct national consumption and exportation | [12,71] |
| **Industrialization and diversification** | Late 1940 to current | Multispecies crustacean fishery red shrimp (*Heterocarpus reedi*), yellow squat and red squat lobster (*Pleuroncodes monodon*) lobster (*Cervimunida johni*) | This fishery stared in the North of Chile and expanded south at the end of the 1960's, due to the depletion of the yellow squat lobster. Currently these fisheries are in the category of full exploitation | [13,72] |
| | 1960 to current | Small pelagic fishery Anchovy (*Engraulis ringens*) and Sardine (*Estrangomera bentincki*) | These catches were mainly intended for the production of fish meal and oil. The anchovy fishery is currently recognized as being over exploited and depleted. | [12,13] |
| | 1970 to current | Jack mackerel (*Trachurus murphyi*) | One of the most important fisheries (in terms of landing) in Chile, with an Historic maximum of 4.4 million tons in 1995. Over the last decade the average catches have averaged of 790 thousand tons per year. This fishery was declared over-exploited. | [13] |

**Table 2**
Historical single-species management approach in Chile.

| Period | Year | Milestones | Description | Refs. |
|---|---|---|---|---|
| 19th century to 1980's | 1800's | Signing of the regulations for fishing ("Reglamento para la pesca") | During this period the control and supervision of the fishing activity went through different ministries. Main focus of fisheries management was to increase production and revenues of the fishing industries. Open access fisheries system, with no clear definition of management objectives and incomplete enforcement of management measures. | [12,14,70] |
| | 1970's | Control and supervision of fishing activity was transferred to the Ministry of Economy Development and Tourism. | | |
| | 1976 | Creation of the Undersecretary of Fisheries and Aquaculture, the fisheries regulatory agency. | | |
| | 1978 | Creation of the "National Fisheries and Aquaculture Service". The institution responsible for maintaining statistics (e.g. landings) and enforcement of the management system. | | |
| 1980's | 1980 | Seasonal fishing closures. | The decline of many fishing stocks in Chile saw changes in the management objectives were put in place. Despite these improvements, many fisheries in Chile remain at low levels of landing compared to their historical highs. | [14] |
| | 1981 | Setting of size limits. | | |
| | 1982 | Fishing quotas (e.g. hakes and jack mackerel) | | |
| 1991–2013 | 1991 | Total allowable catches. | After the advent of democracy, the "Fishing and Aquaculture General Act" is enacted. This new fisheries legislation was thought to improve the management of fisheries in Chile. | [12,14,70] |
| | 1991 | Individual transferable fishing quotas. | | |
| | 1991 | Ratification of the National and Zonal Fisheries Councils | | |
| | 1992 | Creation of the artisanal fishing register | | |
| | 2001 | Maximum catch limit per owner (based on their historical share in catches) | | |

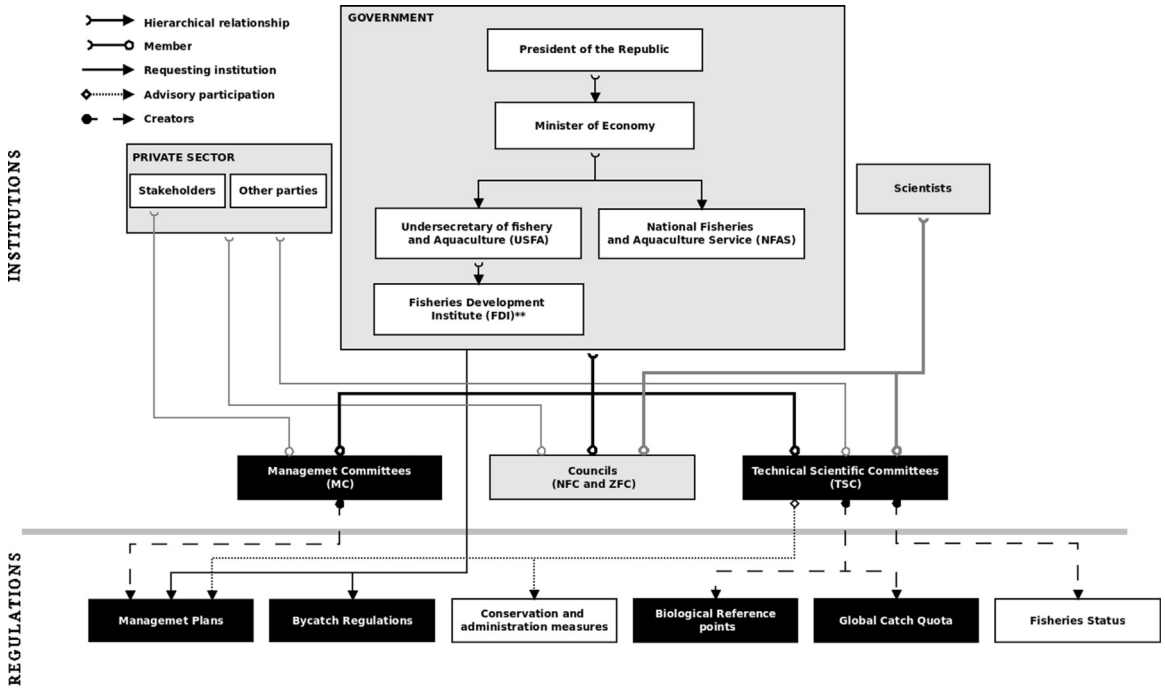


**Fig. 1.** Simplified schematic diagram of institutions and regulations involved in fisheries management in Chile. Black boxes represent the new institutions and regulations created under the new Fishing and Aquaculture General Act. ** IFOP is a private non-profit corporation funded almost entirely by the government.

none was able to control stock declines and now most of the important resources are classified as over-exploited or depleted due their poor biological condition [13]. These failures have been attributed to the lack of appropriate management actions as a result of divergent institutional priorities [14,15], poor compliance and constraints on enforcement of the fishing regulations [14], as well as the institutional organization of the regulatory processes and the structure of the decision making processes [15]. In 2013 the new Fishing and Aquaculture General Act (FAGA) was passed. This Act amends the scope of the sustainability of aquatic resources and presents important changes to the former FAGA. The aim of this new Act is the conservation and sustainable use of fisheries resources through the application of the precautionary approach and EBFM. This new approach to management in Chile was deemed necessary because, while there are some healthy fisheries that are sustainably managed, the overall fishing scenario in Chile is fairly negative [13]. The new FAGA seeks to remedy this problem by implementing a new approach to managing fishing activity, creating a framework with new regulatory bodies and management tools for fisheries management (Fig. 1). Among the most notable changes are: i) development of management plans (MP); ii) establishment of management committees (MC); iii) creation of technical scientific committees (TSC); iv) incorporation of regulations for bycatch; v) establishment of biological reference points (BRP); and vi) change in the responsibilities of the national fishing committee (NFC; more detail Table 3). However, the implementation of such large changes is challenging, as communication between different components (i.e. stakeholders) of this new governance is limited, there are no clear implementation guidelines, nor sufficient additional resources to support the MPs that have been earmarked for development [16].

Chile's actions in regards to EBFM took a further step in May 2016, when the Chilean government announced the creation of the governmental agency for climate change and sustainability (GACCS). This was

an important step for Chile, as climate change is expected to have a significant impact on artisanal fisheries and small-scale aquaculture – due to their low adaptive capacity and constrained access to fishing and trade relations (as compared to their industrial counterparts) [17]. The GACCS will be in charge at a national level of the adaptation and mitigation plans for coping with the effects of climate change [18]; acting as a link between different sectors and strengthening the interaction between the state and the private sector [18]. The creation of the GACCS followed the approval of the climate change adaptation plan in fisheries and aquaculture in December 2015 (CCAPFA; [19]). The main objectives of this plan are: i) generate and improve the knowledge about the impact of different climate change scenarios; ii) improve the regulatory, political and administrative framework to address the challenge of climate change; and iii) develop mitigation and adaptation measures to reduce vulnerability and lessen impacts of climate change on fisheries and aquaculture. This plan reinforces EBFM and the precautionary approach in the FAGA, creating more flexibility and providing tools specially for addressing climate change, something that is missing in the current FAGA [16,19].

### 3.1. From single species management to EBFM

Fisheries management in Chile was and remains focused on a single species approach for the majority of fisheries. The new FAGA seeks to carry out a transition to EBFM, incorporating new management bodies, changing the attributes of others (i.e. USFA, MC, STC and NFC), and ultimately taking the best available information into account [16]. This change does not necessarily constitute an epitaph to current single species management practices [20], but instead calls for the inclusion of ecosystem principles when management decisions are made. A successful transition from single species management to EBFM should have two main components: a governance structure (i.e. institutional framework) and operationalization of the management system.

#### 3.1.1. Governance structure of EBFM

The operation of EBFM requires a governmental structure and a regulatory framework that provides the necessary management tools for use under this new paradigm. Without these structural components the effective implementation of EBFM would be incomplete or defective [1,21]. In Chile, the new Act provides the institutional structure and tools with which to evolve towards EBFM. This institutional framework is made up of a system of governance and institutional participation nested at different scales (councils). This framework also lays out institutional structure, tools and deadlines for the creation of new regulations (BRPs and MPs) and incorporates more stakeholders drawn from different levels of management. However, without sufficient guidance and support to ensure success of the transformation the effort can be undermined. Thus, despite the positive aspects, the current governance structure, fisheries councils, TSCs, and MCs still work at the single species level and are not moving towards EBFM. They do not ensure a broader integration of other stakeholder's interests that address other aspects of the ecosystem. Moreover, the structure of the management councils and committees were not conceived in the context of working regularly at a multispecies or ecosystem levels and does not provide opportunities to discuss problems that involve the ecosystem (e.g. cumulative impacts, risk assessment and ecosystem interactions).

#### 3.1.2. Operationalizing EBFM

Operationalization refers to the establishment of regulation, research, plans and tools for management towards EBFM. In the case of Chile, this involved the creation of MPs, mitigation and regulation of bycatch and the establishment of BRPs. Under this scheme, research programs are carried out by the Fisheries Development Institute (FDI; IFOP) and consist of stock assessments, monitoring of the biological status of fisheries and surveys. This information is used by the TSC to establish the status of the overall fishery, the BRP and the total catch quota. However, the new Act does not specify how the ecosystem is integrated into the fisheries assessment process. In the international context this integration has ranged from the addition of specific ecological or ecosystem considerations [22–24]; to the use of models that explicitly account for the complete or partial structure of the ecosystem [25]; or to the use of ecosystem status reports as a complementary and context stetting addition for council consideration alongside single and multi-species recommendations (e.g. as done for the Bering Sea and Gulf of Alaska [26,27]). It is possible that these approaches can be adapted to the Chilean context. For example, when considering tactical (annual cycle) management decisions single species models could still be used within the constraints of an overall ecosystem-level cap on catches and with a *posteriori* and qualitative consideration of the prevailing ecosystem context (as done in the Bering Sea); or they could be extended to explicitly incorporate ecosystem considerations, with decision rules defined at the ecosystem or multispecies assemblage level. At the strategic level (i.e. when shaping broader policy or thinking on longer time frames) end-to-end models, where the entire system is incorporated, could be used to explore strategic directions [28]. In recent years, globally, the interaction and fusion of single species and ecosystem models has increased markedly resulting in a variety of modeling approaches that differ in complexity and requirements [25]. These tools can assist in addressing the challenge of transitioning from single species to ecosystem-based models and management. The quality and quantity of information available can make this easier (or harder), but should not be presented as an insurmountable barrier to the implementation of an EBFM [20,29].

### 3.2. Assessing Chile's path to EBFM

Chile has incorporated progressive and strategic changes in the new FAGA to help with the transition towards EBFM. Changes that are a challenge for authorities, fishing industries, fishers and the scientific community. Thus, it is worth asking: Are these modifications helping the transition towards EBFM? Is there coherence between the proposed policies, measures and institutional changes?

The Food and Agriculture Organization of the United Nations (FAO) provides a framework for determining if these steps are helping in the transition towards EBFM [1]. Using this guideline, it is observed that these changes in the FAGA are reflected in several objectives and operational measures.

#### 3.2.1. Inventory of objectives

- **Targets, constraints, indicators and reference points**
  This operational principle is mainly reflected in the establishment of the BRPs. In the FAGA, BRPs are based on the use of MSY and reflected in three fundamental components of the new Act: i) the establishment of the global catch quota per species; ii) the development of the management plans; and iii) identification of a BRP on which the status of the fishery will be defined [16].
  The selection of MSY as the BRP is perhaps unsurprising as it has been commonly used as a reference point in single species management and many of the international management regimes have been constructed around this concept [30]. However, while the formal introduction of a BRP into the FAGA is laudable, the use of MSY as a target BRP has been widely questioned and discussed [31,32]. Because of the assumptions and the problems associated with its application the implementation of MSY as a management objective can generate negative effects on the management of fishery resources [3,30,32–35]. At the ecosystem level it has been established that the use of conventional single species MSY can have a negative impact on the functional structure of the ecosystem [32–34]. Moreover, MSY cannot be obtained for all species simultaneously [33]. Even if it could be achieved, current

recommendations indicate that the use of MSY should be avoided in recovery plans because of the negative effect on species ecotrophically connected with the fishery resource [1,33]. This is especially true where fishing has unwanted effects on the dynamics of other species in the ecosystem, via (for example) predator-prey interactions [33,34]. In multiple species fisheries the aggregated yield obtained from fishing at their individual MSY levels is expected to be lower than that sum of the individual MSY in the aggregation [33]. This means that the aggregate MSY calculated at the level of an ecosystem tends to be less than the MSY calculated as single-species. This evidence suggests that it is risky and non-precautionary to use MSY as a target reference point or management objective, especially under an ecosystem approach [32–34]. It has been proposed that the MSY should instead be used as a limit reference point – that is, to be avoided [1,3,35].

Chile could perhaps draw lessons from other jurisdictions that have amended legislation referring to MSY: transforming MSY into a limit reference point [30] and proposing new target reference points; or requiring additional relevant ecosystem factors be considered (i.e economic, social, or ecological).

While many of the pieces of fisheries legislation globally still use MSY, even under an ecosystem framework, a substantial number of these Acts have amendments that adjust or redefine the MSY using relevant ecosystem factors (i.e economic, social, or ecological), transforming MSY into a limit reference point [30] and effectively proposing new target reference points.

#### 3.2.2. Review of interactions

- **Improving conventional management; improving the institutional set-up; improving the decision-making framework and management planning**

  All these operational principles are reflected in 4 important changes produced by the new Act:

  – *Management Plans and Management Committees*

  One of the first components that must be defined in EBFM is the direction in which to focus the management [1,11], namely to set the objectives and guidelines under which management rules will be determined. These rules contained in the MPs are the fundamental basis of the application of EBFM [11]. The development of these MPs should be encouraged and supported by the fishing authority and be a continuous participatory process (during all the management phases), including all the stakeholders [1,11,36]. The mandatory creation of MPs is a major breakthrough in the new FAGA for several reasons. Firstly, it formally establishes guidelines for management, making rules, regulations and management objectives visible to all stakeholders [11]. Secondly, it generates a clear signal of commitment from the fisheries authority to take actions [1]. Finally, it generates a more stable management scenario. However, as noted above implementation at the scale required is not without its challenges, which could threaten the effectiveness of the intent.

  – *Technical Scientific Committees*

  The creation of these committees (Fig. 1; Table 3) has been a major change for fisheries management in Chile, because it separates the assessment of resource status and (technically-based) identification of catch quotas from political/economic-based management and decision-making processes. This contrasts with the previous management process, where the technical advice could be modified by the NFC during the final quota-setting steps [15].

  – *The Fisheries Councils.*

  The new Act ratifies the councils but makes several changes in their functions. One of the major changes introduced by the new Act establishes that the NFC cannot decide on annual catch limits [16], seeking to avoid short-term prioritization of socio-economic objectives, which occurred in the past [15]. Previously, while the USFA recommended a TAC based on scientific information, the NFC had the power to modify it [14,15]. This ability to set TAC levels beyond those recommended scientifically threatened the conservation of stocks and sustainability of many important fisheries, as the structure and interest of the NFC members frequently prioritized short-term social and economic objectives [15].

The currently proposed organizational structure of these management institutions (MCs, TSC, NFC and ZFC) does not ensure the participation of other stakeholders concerned with other ecosystem issues related to fisheries and aquaculture (i.e. conservationists, NGOs and scientists). This could be a problem for the effective implementation of EBFM (and ultimately fully integrated ecosystem management across all marine activities) in Chile. The discussion among different stakeholders is vital for determining which ecosystem services they want and what are the ways to achieve them [1,21]. An effective organizational structure should avoid unnecessary expansion, but should include the greatest possible diversity of stakeholders (going beyond a single production sector), which would mean adding additional representatives such as community and NGOs to the existing council membership [21,36–38]. It is true that the addition of more stakeholders has a higher cost and will require greater human and institutional effort, but experience has shown that the resulting management is more effective, comprehensive, inclusive and engenders greater commitment from the different interest groups [21,38].

- **Maintaining biological diversity; reducing bycatch and discards.**

  These operational principles are reflected mainly in the provisions of the new FAGA to address bycatch (Table 4). Bycatch is an inevitable outcome of mixed fisheries that can have unwanted effects on the dynamics of an ecosystem [39,40] and has been recognized by FAO as one of the major threats to fisheries' sustainability. The step-wise structure proposed by the new FAGA (i.e. gathering information - management measure - evaluation; Table 4) allows for the development of appropriate bycatch management measures and assessment of their effectiveness [40]. Currently, the Chilean management institutions are working on the second stage of implementation and the following measures have been proposed: i) starting in 2018 the global catch quota will be set for the total fish caught not for the total fish landed; ii) the discard ban compliance will be monitored by electronic monitoring systems; iii) establishment of mitigation plans. The use of bycatch information across multiple components of fisheries management (such as stock assessment or management plans) is a necessary step in the search for sustainable resource management [40] and implementation of EBFM [39,40]. Among the measures recommended and adopted elsewhere in the world are: i) implementation of a total allowable bycatch level by fishery (TAB) [22,40]; ii) incorporation of bycatch data into single species stock assessment models [39]; iii) ecosystem models that explicitly include the bycatch [41]; iv) spatial and temporal measures, such as restricting or prohibiting the use of certain types of fishing gear in some areas; and iv) bans on returning catch to the water, where applicable, providing that the catch cannot be returned alive [40,42,43]. The new FAGA also creates incentives for technological development of bycatch mitigation [16]. This type of regulation is widely recommended because it makes the implementation of new technologies (e.g. increases in fishing gear selectivity to avoid excessive bycatch) more likely [40]. Especially, as a result of the implementation of this new technology, there may be an improvement in profits, catch quality, efficiency or safety [40].
- **Protecting selected marine areas; protecting and enhancing habitats**

  Although this is not addressed directly in the New FAGA, Chile has commitments with international organizations in this area. In 2006

**Table 3**
Major changes in institutions and policies under the new Fisheries and Aquaculture General Act in Chile.

| Institutions or policy | Description | Constituted or controlled by |
|---|---|---|
| Management Plans (MP) | Mandatory creation of MPs for fisheries with closed access (i.e. closed to new operators), recovery regime and underdevelopment, | i) management objectives; ii) procedures to achieve these objectives; and iii) means of assessing performance and achievement. |
| Management Committees (MCs) | The MCs are in charge of the development of the management plans for each fishery. | i) fishermen, both industrial and artisanal; ii) processing plants; iii) the fishing authority; and iv) (indirectly) the technical scientific committees as consultants. |
| Technical Scientific Committees | These TSC are advisory or consultation bodies of USFA and are responsible for: i) assessment of stock status; ii) establishment of biological reference points (BRP); and iii) determination of the range within which the overall catch quota can be set. | i) members selected by public contest (i.e. independent fisheries science experts); ii) officials from government agencies (i.e. USFA); iii) members from the Fisheries Development Institute (FDI; IFOP); and iv) non-voting members consisting of people with particular interests in the fishery (i.e. research entities linked to the industry). |
| The Fisheries Councils | Ratification of the national council (NFC) and 8 zonal councils (ZFC) divided by geographical regions. These councils are consultative bodies that contribute to the involvement of different agents of the fisheries sector on matters related to fisheries and aquaculture. One of the major changes introduced by the new Act establishes that the NFC cannot decide on annual catch limits. | NFC: 3 officials drawn from government institutions, 17 people related to fishing activities and 7 external consultants nominated by the government. ZFC: 6 officials drawn from government institutions, 11 people related to fishing activities and 3 external consultants. |
| Biological Reference Points (BRPs) | The BRPs under which the status of the fisheries will be defined must be established. In the new Act, these BRPs are determined under the paradigm of maximum sustainable yield. | Technical Scientific Committees |
| Bycatch mitigation | To minimize discarding and catching bycatch the new fishing Act mandates the gathering of bycatch information, determination of its impact, generation of mitigation measures and an evaluation of the adopted measures. | Undersecretary of Fisheries and Aquaculture |

the Convention on Biological Diversity called for an international commitment to protect at least 17% of the marine areas by the year 2020. After this commitment, there has been a substantial increase in the number and total area demarcated as parks and marine protected areas in Chile, reaching almost 13% of Chile's exclusive economic zone. While this could be seen as good for conservation, in reality, many of these areas are “paper parks” that do not have effective management [44,45]. To better face the challenges of achieving the objectives of international conservation agreements, the obsolete management plans must be updated and more effective and adaptive management plans for the protected areas implemented [44]. Despite having a large number of MPAs, the benefit of this institutional effort in terms of conservation can be null or very low, if these areas are not effectively managed or in locations that are not representative of the breadth of Chilean ecosystem types and biodiversity.

- **Matching jurisdictional and EAF boundaries**
  In the new FAGA, the structure of management institutions is still based on a single-species approach which has been one of the main problems faced by fishery management in its transition to EBFM. Nowadays, hard management boundaries (based on a single species or area) are not an appropriate option if fisheries management seeks to: i) account for the processes and interactions of ecosystems, ii) sustainable ecosystem management and iii) to be prepared to face the challenges of climate change. All this is even more critical when it is considered that these ecosystems are already changing due to environmental changes, including species migrating to other ecosystems [46]. Having flexible management based on ecosystem boundaries makes the management bodies more capable and resilient to those challenges. The creation of institutions (e.g. management and scientific committees) by ecoregions ensures that governance (i.e. research, management measures and MPs) is tailored for the ecosystem and not merely species by species. Many countries like USA, Australia or the EU have management councils by ecosystems that help them to focus the governance in each specific ecosystem. Chile has 8 marine ecosystems based on oceanographic and biological systems [47]. The management and research can be organized around these systems. For example, ecosystems such as islands, archipelagos, or seamounts (e.g. Juan Fernández Archipelago, Easter Island) are quite different from fjords (e.g. Chiloe inland sea). Therefore, to embrace EBFM it is necessary to change the way in which Chile divides the fishery management councils and committees. A starting point may be to use already recognized ecosystem boundaries as the basis for the creation of fisheries management institutions. Specific management councils and committees can also be created for species groups that migrate between these ecosystems (e.g. mackerels). In addition, by taking an ecosystem rather than stock perspective, the participatory management burden is reduced, dropping the number of required management plans (for example). Thus, the scope to recognize the interconnected nature of stocks exploited in a single region can be addressed while simultaneously making the process more tractable. Without such rationalization the entire intent of the new FAGA runs the risk of being eroded and there is the risk of dis-engagement and participatory fatigue [38]. Such outcomes are a risk associated with the selective adoption of (often strongly promoted) management components from elsewhere without appreciation of the associated underlying rationale and context.
- **Certification.**
  Although not part of the new FAGA, in recent years many Chilean fisheries are been certified. These certifications have primarily used the eco-labeling standard granted by the Marine Stewardship Council (MSC). These certifications were an initiative of, and developed by, fishers and have had the support and guidance of the government. While these certification systems do not by themselves ensure the sustainability (ecological or social) of the ecosystem in the long term [48], they can be a good way to measure and promote the objectives of EBFM [1].
- **Priority setting; improving ecosystem well-being; rebuilding ecosystems; maintaining reproductive capacity of target resources; reducing uncertainty and risk; monitoring and indicators; improving research capacity; improving statistics and inventories; and reducing ghost fishing**
  These operational objectives are not addressed directly in the new FAGA but most of them are overlapping or nested in the objectives mentioned above. Although, many of them are reflected in several areas that have advanced towards an EBFM, in general there is little or no representation of these in the Chilean fisheries legislation or their approach is mono-specific. Many of them have a limited definition, do not have a clear development plan or objectives or lack measurable performance measures for their implementation. In fact, some of these indicators are classified by FAO as fundamental in the

transition to an EBFM and that are not addressed or are poorly represented in Chilean legislation (e.g. Priority setting, Improving Ecosystem Well-being, Ecosystem rebuilding). The progress towards an EBFM is thought of as a step-wise approach, which is why not all of these objectives and measures have to be developed immediately, some can be developed in the future. However, it is necessary to prioritize those that are most urgent [1].

### 3.3. Does the implementation of EBFM in Chile suit all its fisheries?

#### 3.3.1. Industrial fisheries

There is no single way to implement EBFM. In fact, there are several countries managing their resources under a range of different approaches but coordinated through an EBFM framework. There are also a significant number of scientific publications and technical guidelines that address different problems pertaining to the implementation of EBFM. This constitutes a valuable reservoir of approaches for the implementation of EBFM. For the Chilean system (and for others) it is foreseen that the implementation of an EBFM may follow two pathways:

- Adapt the approach of EBFM already used for the management of other ecosystems to the context of local conditions. There are many fisheries worldwide that are managed under an EBFM framework, which are similar to the operational dynamics of Chilean industrial fisheries [22,24,43,49–52]. These fisheries have developed approaches, strategies and solutions to address the challenges of integrating EBFM. Adapting these approaches would be a good first step to transitioning to EBFM.
- Use existing best practice guidelines to shape Chilean specific EBFM *de novo*. Due to the interest in the implementation of EBFM several guides and scientific documents have been developed to help the transition to EBFM (see [1,28,37,53]). These guidelines supply technical support, advice and tools for the development and implementation of EBFM under different social, ecological and management scenarios.

No matter which of these two possible paths is taken, an important requirement is a sensible adaptation of EBFM to local conditions [1]. This involves interactions between different stakeholders, reaching consensus among them (often with different priorities) and the search for solutions to potential conflicts.

#### 3.3.2. Artisanal fisheries

Most artisanal fisheries have characteristics that create major challenges for the fisheries management system and will undoubtedly do so in the implementation of EBFM. These characteristics are:

- These fisheries are generally associated with the coastal zone, which are potential sites of conflict with other users and industries (e.g. tourism, recreation, urban and industrial development)
- Substantial socio-economic importance, often interconnected with fragile communities [54,55]. This means that any mismanagement has the potential to have a large negative impact in the community.
- Despite representing a substantial volume of landed catch, they are hard to monitor, control and enforce, due to the large number of participants and landing sites scattered along the coast, which makes it technically difficult to conduct surveillance or effectively monitor these fisheries.
- Limited available scientific information associated with these fisheries, often ranked as data-poor fisheries under scientific standards [56].

While these characteristics result in major challenges for fisheries management they are not a complete barrier to the implementation of EBFM. The consideration of the following factors can aid to overcome these challenges:

- **Development of rules based on participatory management**
  In artisanal fisheries, the role of users has proven to be critical in the pursuit of sustainability of ecosystems [56–58]. In contrast, top-down structures often operating with command-and-control rules, have not worked satisfactorily in most cases [59,60]. Therefore, in the quest for ecosystem sustainability, it is necessary to generate the appropriate mechanisms to ensure diverse stakeholder participation at all levels of EBFM implementation [56,57,60]. This integration generates a sense of ownership which encourages more responsible use of the resources [54,57,59,61]. It also leads to more adequate management measures, because they include local and traditional knowledge associated with the fishing dynamics, socio-economic and ecological processes [57,61]. This comes hand-in-hand with greater incentives for participation in monitoring, surveillance and control of resources by the stakeholders themselves [61,62]. Lastly, it results in greater participation in the implementation and enforcement of management regulations [61,62]. This management system, like many others, has to be continually modified and improved to create more resilience and the ability to adapt to new challenges [60,63]. This is achieved mainly by strengthening the interaction of the actors under the guidance and support of government agencies [60].
- **Recognition of non-traditional management and collective actions**
  Artisanal fisheries are socio-ecological systems with complex interactions of socio-economic and ecological processes. Overlooking this complexity has been recognized as one of the causes of management failure [61,64]; resulting in management measures often distant from local conditions and the fishing and ecological dynamics [61,64]. This has given rise to problems such as poverty, marginalization, social displacement, food insecurity, cultural and social stress, and resource depletion [56,61,62,64]. Where artisanal fisheries have successfully avoided over-exploitation, it has been attributed to the successful collective action of management and governance of common resources [54,61,62,64]. Many of these fisheries are managed under a mixed system of regulations that control the extraction of resources [54,65]. These mixed measures are composed of a formal management component, usually from a regulatory institution, as well as informal management regulations, which are generally based on unwritten rules and agreements derived from understanding and commitments made among fishers [54,65]. The informal components (often based on tradition) have been reported as the main component of the successful management of many small-scale fisheries [54,59].
- **Data-poor fishery**
  While data poor fisheries are very common in developing countries, especially in the context of artisanal fisheries [11], it is still possible to implement EBFM [2,11,20,29]. It is a misconception that implementation of EBFM can only be carried out in places with data-rich fisheries [20,29]. There are numerous approaches and methodologies for implementing EBFM which range from quantitative, through semi-quantitative to qualitative methods [25,28,29,66]. The decision regarding which approach to use will depend on the information available. In both data-rich and data-poor fisheries, in the absence of a complete ecosystem assessment, hierarchical ecological risk assessment is a particularly useful approach of assessing what ecosystem factors have to be prioritized [29,37,67].

## 4. Conclusions

Chile is one of the major fisheries and aquaculture production nations worldwide. The over-exploited state of many of its fisheries has generated concern and driven changes in the management approach. The new fisheries and aquaculture management Act has EBFM and the

precautionary approach at its core, as it seeks more sustainable resource management. Adoption of EBFM has required multiple modifications including: the compulsory creation of fisheries management plans, changes to the institutional structure and decision-making processes, and the creation of new mechanisms to strengthen knowledge regarding the impact of fisheries on the ecosystem. The EBFM concept derives much of its strength from work that examined the need to move to integrated approaches to fisheries management centered on the ecological interactions underpinning fishing. At the same time attention needs to be given to institutional arrangements and administrative processes – that contribute to management capacity, policy development and implementation, that is the core of policy coherence. While key work to ensure coherence of outcomes is likely to enhance successful implementation, it is important, to recognize that there is no "one best way" to ensure effective implementation of EBFM programs. As Chile's experience identifies there are a large number of factors involved – including national priorities, regional commitments, international obligations and external drivers. These external drivers are important in the development of priorities and strategies at different scales, such as for artisanal fisheries. The management framework provided by the new Act places Chile in a good position for the effective implementation of EBFM. This management approach is suitable for all types of fisheries, different levels of information and different social contexts. Chile has the scientific and legal capabilities to move towards integrated and sustainable management of their marine ecosystems. Under the current condition of Chilean marine resources, the implementation of EBFM is necessary and urgent. While this implementation requires enormous institutional and human effort, with the right political impetus (and some amendments to its operationalization) it is possible. Despite the generally positive changes from Chile's implementation of EBFM, the new Act has three important area that would benefit from review or amendment.

- Fisheries institutions (e.g. MCs, TSC, ZFC) should be structured around ecosystems to ensure an adequate implementation of EBFM. The current designation of these institutions to a single species scope undermines the coherence of EBFM in practice and creates an excessive load on participants, which might be lessened by an ecosystem oriented aggregation of council responsibilities (i.e. bring together all species from a single ecosystem under the one council).
- Fisheries management processes must allow for inclusion of a more diverse group of stakeholders (recognizing that fishery and aquaculture are part of the food provisioning system, which is just one of many services that the marine ecosystems provide). This will have a direct impact on the robustness of the decisions taken and agreements made.
- The use of MSY in fisheries management must be reviewed and revised. The focus of EBFM suggests that MSY is more appropriates as a biological limit rather than a target reference point.

While Chile has made significant changes to its fisheries management system the identification of these three areas indicates some incoherence between policy objectives, policy development and implementation. Greater effort is needed to build support for EBFM through institutional reform that will build management capacity. Development of broader-based stakeholder engagement, through more formal processes is also needed. Attention to the introduction of new tools, such as the use of more appropriate biological limit reference points in harvest strategies and processes will complement these institutional reforms. These amendments can build on the current policy base provided by the new Act.

Even without these changes in place, is EBFM applicable to all types of fisheries? The short answer is "yes". The implementation of EBFM is a beneficial management paradigm for all types of fisheries around the world with many facing the same management problems as Chile. So, it is possible to be guided by how EBFM is implemented in these other fisheries, modifying and adapting their solutions to suit the Chilean context in both industrial and artisanal fisheries. In artisanal fisheries, the implementation of EBFM constitutes a bigger challenge – due to a broader range of stakeholders, internal regulations, diffuse nature and data poor status. The main need for the implementation of EBFM in the artisanal fisheries is the understanding of the customary rules of each fishery i.e. the internal (socially mediated) management rules. The use of alien and generic top-down management measures can have a strong negative impact on the management of artisanal fisheries and can weaken the implementation of EBFM and the sustainability of the resources. This means that each artisanal fishery will have its own way of incorporating EBFM; necessitating participatory management with the support and guidance of the management institutions. Chile is in a strong position to make the most of the opportunity presented to them by the requirement to transition to EBFM; to implement the governance and other tools required to manage Chilean ecosystems in a more effective, integrative and robust way, thereby placing the country in an excellent position to face the future challenges of climate change and food security.

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